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Comparison of magnetic resonance diffusion-weighted imaging characteristics between cystic lesions and normal pancreatic parenchyma

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ABSTRACT

Introduction: Diffusion weighted imaging (DWI) is a form of magnetic resonance imaging (MRI) based on measuring the random Brownian motion of water molecules within a tissue. The aim of this study was to show the significance of diffusion-weighted imaging (DWI) in differentiating pancreatic cystic formations from normal pancreatic parenchyma using MRI 1.5 T.

Methods: A total of 52 patients were included in the study (25 with pancreatic cystic formations and 27 with normal MRI findings of the pancreas). DWI technique was used with b values of 0.500 and 1 000 mm²/s at 1.5 T. The signal intensity was measured, as well as apparent diffusion coefficient (ADC). Visual estimation of the signal intensity of detected cystic lesions was performed and compared to the normal appearance of pancreas.

Results: The highest signal intensity of the cystic lesions with hyper-signal was observed with DWI b0 value in the pancreatic head (M 185.1 ± 47.205, $p < 0.05$). Similarly, the highest apparent diffusion coefficient (ADC) value of the cystic formations with hyper-signal was observed in the pancreatic head (2.09 x 10^{-3} mm²/s, $p < 0.05$). In the group with healthy pancreas, the highest signal intensity was observed with DWI b0 value (M 76.40 ± 18.28, $p < 0.05$). The observed ADC value in this group was 1.21 x 10^{-3} mm²/s in the head, 1.24 x 10^{-3} mm²/s in the neck, 1.21 x 10^{-3} mm²/s in the body, and 1.06 x 10^{-3} mm²/s in the tail; $p > 0.05$.

Conclusions: Differences in signal intensity and ADC values have an important diagnostic value in differentiating the cystic formations from normal pancreatic parenchyma in MRI examination.

Keywords: Diffusion weighted imaging; magnetic resonance imaging; pancreas; cystic formations; normal pancreas appearance

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INTRODUCTION

The pancreas is an endocrine gland that can be divided into four parts: head, neck, body, and tail (1). Along with its shape, the location of pancreas in the abdomen often affect the quality of MRI scans. Even the most experienced engineers of

radiology have problems in achieving a good quality MRI image. Bowel peristalsis, respiratory motion, and the pulsation of heart and blood vessels are the factors that contribute to obtaining a MRI image with artifacts. Motion artifacts, especially ghost artifacts, can lead to the loss of image clarity and decrease the visibility of anatomic details, thus limiting the discovery of pathological lesions in the abdomen (2).

In some cases, even the additional control of respiratory motion and breath-hold sequences does not provide good results. In these situations, the bad image quality can lead to false positive or false negative results. At our department for pancreas MRI examinations, conventional spin-echo (SE) and turboSE (TSE) T1-weighted (T1w) and T2-weighted (T2w) sequences are used in routine protocols with and without fat saturation, in order to discover even the smallest possible pancreatic lesions. Diffusion-weighted imaging (DWI) is a new technique that has been increasingly used in diagnostics of different pancreatic lesions that can be categorized as cystic or solid lesions. Unlike conventional MRI sequences, this technique enables the measurement of diffusion coefficients in the tissue, as well as the monitoring of morphological appearance of the lesions. This sequence enables breath hold imaging of molecular motion of small water molecules in the tissue, based on Brownian motion.

Diffusion coefficient represents the distance that molecules pass in the stochastic motion in a time unit, measured as length x length/time (expressed in mm^2/sec). Hence, a particle with a high diffusion coefficient moves in a wide area, whereas a particle with a low diffusion coefficient moves in a limited area (3).

MR-DWI has improved the pancreas diagnostics. The technique is more often used for whole-body imaging, but the latest studies showed its implementation in pancreas imaging. DWI technique can be useful as a supplemental imaging method in differentiating between the focal masses and pancreatic adenocarcinoma. ADC values obtained with DWI can differentiate between simple pancreatic cysts, inflammatory cysts, and pancreatic cystic neoplasms (4).

Pancreatic pseudocyst is defined as a fluid collection, rich in amylase and pancreatic enzymes, that has non-epithelialized wall composed of fibrosis and granulation tissue, and that appears usually few weeks after the onset of acute pancreatitis. Pancreatic pseudocyst forms during the disruption of cell wall and release of pancreatic enzymes into the surrounding tissue (5).

Cystic epithelial pancreatic neoplasms, such as serous cystic tumor, mucinous cystic tumor, solid pseudopapillary tumor, and intrapapillary mucinous neoplasm (IPMN) have different MRI characteristics compared to pancreatic adenocarcinoma. In pathology, serous microcystic adenoma is large [mean diameter 6 cm] (6).

Serous cystic tumors are usually hyperintense on T2w MRI, although some central areas of low signal intensity can be occasionally observed as a result of fibrosis or calcification (7).

Normal organ appearance (in this case pancreas) is relatively easy to observe on DWI. But organs affected by disease have different appearances on DWI. The impact of various pathological states, such as tumor, abscess, ischemia, and fibrosis affects water diffusion and organ appearance on DWI. To what degree water motion will be affected can be calculated using set of ADC maps from diffusion scans acquired with different b values (8).

The aim of this study was to demonstrate the significance of DWI in diagnosing pancreatic cystic formations, to incorporate DWI into standard procedures, as well as to simplify the detection of pancreatic cystic formations.

METHODS

Patients
The study was conducted at the Clinic for radiology, Clinical center of University of Sarajevo, during the period between December 2015 and July 2016. This study included 52 male and female patients, of different age groups, who were referred to MRI examination of the pancreas. According to MRI characteristics, in 25 patients, pancreatic cystic lesions were detected, and normal MRI findings of the pancreas were verified in 27 patients. Before the

imaging procedures, the patients gave their written consent to perform the procedure, as well as the written guarantee that there were no foreign metal bodies nor metal implants that could cause damage to patients during the MRI examination.

Procedures

The patients were scanned in supine position, flexible body matrix coil was placed over the upper abdomen. Before the beginning of procedure, the patients were instructed how to cooperate during the procedure and what to do in the case when the procedure should be interrupted. A safety pump that is used to alarm the staff to stop the procedure, was placed in a hand of every patient. All parts of the pancreas were included in the examination field. Every patient underwent standard examination of the pancreas at the Clinic for radiology with the Avanto 1.5 T machine (Siemens, Germany), using the standard protocol for scanning the pancreas that includes T1 and T2 sequences with and without fat saturation, as well as a diffusion sequence.

Basic data on DWI sequence were: Slices 30, Dist. factor 20%, FoV read 380 mm, FoV phase 81.3%, Slice thickness 4.0 mm, TR 3900 ms, TE 76 ms, Diff. weightings 3: b value 1 (0 s/mm^2), b value 2 (500 s/mm^2), b value 3 (1000 s/mm^2), and Bandwidth 1736 Hz/Px. The findings were read independently by three radiologists who have multiple years of clinical experience.

The acquired images were evaluated on the evaluating console on Syngo software B13 (Siemens, Germany). Cystic pancreatic lesions were analyzed and compared to the normal MRI findings. Every cystic lesion was marked by region of interest (ROI) taking care that no blood vessel nor any other organ in the abdomen was included. The pancreatic segments were also marked by ROI taking care of blood vessels, and diffusion coefficient value being acquired. In addition to ADC measurements, the morphological appearance and the type of signals in the cystic lesions and normal pancreatic segments were also monitored.

Statistical analysis

Statistical Package for the Social Sciences (SPSS) version 20.0 was used for statistical analysis. Data were analyzed using descriptive statistics (percentages, means and standard deviations). For testing the differences between the arithmetic means, one-sample t-test and one-way analysis of variance (ANOVA) were used.

RESULTS

Out of the total 52 patients, there were 25 (48%) patients with the cystic formations and 27 (51.9%) with normal MRI findings of the pancreas. In the group with the cystic formations, there were 6 (11.5%) male and 19 (36.5%) female patients, with the mean age of 59 years. In the group with normal MRI findings, there were 9 (17.3%) male and 18 (34.1%) female patients with the mean age of 53.4 years.

In the group with the cystic formations, the signal intensity of the cystic formations on DWI sequence with b0 value differed between the pancreatic head and pancreatic body and tail (F = 5.382; $p < 0.05$). A statistically significant difference in the signal intensity of the cystic formations was observed between the pancreatic parts scanned by DWI with b0 value (F = 5.382; $p < 0.05$). The highest signal intensity in the cystic formations was recorded in the pancreatic head (M 185.1 ± 47.205). On contrary, when using DWI b500 and DWI b1000 values no significant difference was observed between the pancreatic parts (F = 0.742; $p > 0.05$; F = 1.071; $p > 0.05$, respectively). Furthermore, the highest signal intensity in the cystic formations was measured with b0 value. Moving from b0, over b500, to b1000 the signal intensity in the cystic formations decreased. ADC values of the diffusion coefficient differentiated going from the pancreatic head to the tail. The highest diffusion coefficient was observed in the cystic formations of the pancreatic head (2.09 x 10^{-3} mm^2/s), then in the body (1.66 x 10^{-3} mm^2/s), and the lowest diffusion coefficient was observed in the cystic formations of the pancreatic tail (1.46 x 10^{-3} mm^2/s) [F = 21.256; $p < 0.05$] (Figure 1).

In the group with normal appearance of the pancreas, the signal intensity of the pancreatic segments on DWI with b0 value was different in the head compared with the neck, body, and tail. A statistically significant difference was observed in the signal intensity on DWI with b0 value between the

pancreatic segments (F = 4.375; p < 0.05). The highest signal intensity with b0 value was observed in the pancreatic head (M 76.40 + 18.28). The signal intensity of the pancreatic segments on DWI with b500 value was different in the tail compared to the head, neck, and body. A statistically significant difference was observed in the signal intensity on DWI with b500 value between the pancreatic segments (F = 3.922; p < 0.05). The highest signal intensity with b500 value was detected in the pancreatic tail (M 34.82 + 13.36). The signal intensity of the pancreatic segments on DWI with b1000 value differed between the head and the neck, body, and tail. A statistically significant difference was observed in the signal intensity on DWI with b1000 value between the pancreatic segments (F = 2.936; p < 0.05). The highest signal intensity with b1000 value was observed in the pancreatic head (M 28.35 + 41.74). There was no statistically significant difference in ADC values, between the head (1.21 x 10^{-3} mm²/s), neck (1.24 x 10^{-3} mm²/s), body (1.21 x 10^{-3} mm²/s), and tail (1.06 x 10^{-3} mm²/s) [F = 0.695; p > 0.05]. The highest diffusion coefficient was observed in the pancreatic neck (1.24 x 10^{-3} mm²/s), but this result was not statistically significant (Figure 2).

DISCUSSION

In this study, the highest signal intensity of the cystic formations was observed in the pancreatic head with DWI b0 value. The low b values provided stronger signal intensity of the cystic formations (hyper-signal), similar to T2w technique, while the high diffusion b values provided weak signal intensity of the cystic formations (hypo-signal). Wang et al. indicated that because of faster, random motion of water molecules in the surrounding area, abundant in fluid, pancreatic cysts show higher signal intensity on a DWI image with b value 0 s/mm2 and lower signal intensity on the image with high b value (9).

Diffusion coefficient of the cystic formations shows higher ADC values of the cystic formations in the head, and lower ADC values in the body and tail. Pancreatic cystic formations are displayed in hyper signal on ADC map.

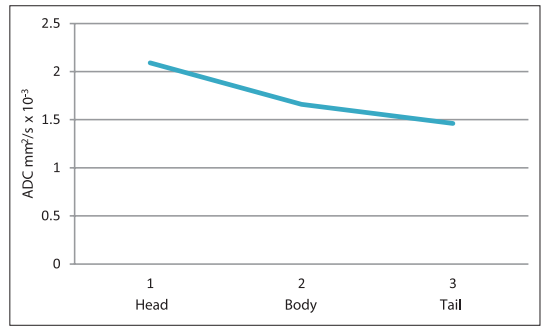DWI signal intensity and ADC values are important because these parameters can sometimes show the

FIGURE 1. Apparent diffusion coefficient (ADC) values of pancreatic cystic lesions. In the group with the pancreatic cystic formations, ADC values showed a decline, going from the pancreatic head to its tail.
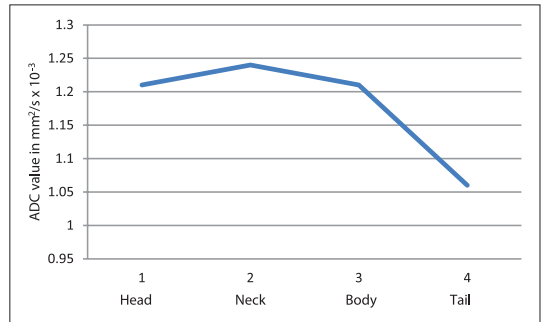

FIGURE 2. Apparent diffusion coefficient (ADC) values of normal pancreatic parenchyma. In the group with normal pancreatic parenchyma, the ADC values showed a decline, going from the pancreatic head to its tail.

changes that cannot be observed on conventional MRI images (10).

Our results showed that, in the group with normal pancreatic parenchyma, the highest signal intensity was recorded in the pancreatic head on DWI with b0 values, and the lowest was observed in the pancreatic tail. DWI with low b values displayed higher signal intensity of the pancreatic segments, in the group with normal pancreatic parenchyma, compared to higher b values, except for the result obtained in the pancreatic tail on DWI b 500, where higher signal intensity was recorded in the tail compared to the pancreatic head. Diffusion coefficient of the normal pancreas displays higher diffusion coefficient on the pancreatic head compared to the body and tail. In another study, ADC values were significantly different between the pancreatic head,

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body and tail, where ADC values decreased toward the tail (11). Available studies show that measured ADC values of normal pancreatic parenchyma on DWI significantly vary in relation to other factors, such as: age, anatomic part of the gland, and magnetic field strength. For example, it was demonstrated that the measured ADC values in the pancreatic tail are lower compared with the ADC values in the other pancreatic parts, which is probably due to the differences in the surrounding tissue. As a person becomes older, the pancreas shows changes related to the age, such as: atrophy, fat infiltration, and fibrosis (8).

CONCLUSION

Because of the differences in the signal intensity between the cystic formations and normal pancreatic parenchyma, DWI can be used as an additional diagnostic tool to improve the diagnostics of the pancreas by MRI.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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